JEDI-GEOS: A pathway to operations at NASA/GMAO

Ron Gelaro, Dan Holdaway, Ricardo Todling

NASA/GMAO

Contributions from Virgine Buchard, Fabio Diniz

10th AMS Symposium on the Joint Center for Satellite Data Assimilation
Virtual, 23 – 27 January 2022

Background

GMAO is developing a unified coupled data assimilation system, based on GEOS and JEDI, for weather analysis and prediction, reanalysis, composition forecasting, and S2S prediction.

A significant challenge will be the coordination of this development with other high-priority GEOS plans, including a major upgrade of the model physics and vertical resolution in the next year.

We'll pursue a multi-phase development approach to allow coupled development to proceed in a timely manner while allowing other important milestones to be met.

GMAO core products

Analysis and Prediction	
GEOS-FP (Forward Processing)	Real-time NWP with hybrid 4D-EnVar, aerosol assimilation, FSOI *Target an intermediate JEDI-centric system in late 2022*
GEOS-IT (Instrument Teams)	Real-time meteorological fields for NASA Instrument Team support
GEOS-CF (Composition Forecasting)	Analysis and forecasts of air quality using complex chemistry model
GEOS-S2S (SubX-to-Seasonal Prediction)	Nine-month coupled prediction with ocean data assimilation, aerosols

Reanalysis	
MERRA-2	Atmospheric climate reanalysis, with aerosols and ozone (1980-2025)
MERRA-2 Ocean	Ocean reanalysis with coupled model (1982-2025), begun in 2021
GEOS-R21C (Reanalysis of the 21st Century)	Modern atmospheric baseline (2000-2025), to begin in 2022
MERRA-3	*Planned JEDI-based coupled Earth system reanalysis, to begin ~2025*

Targets for JEDI-GEOS coupled system

GEOS Coupled Model

- FV3+GEOS physics - atmosphere
- GEOS Chem - composition
- MOM6+CICE6 - ocean/sea-ice
- Wave Watch III - waves
- Land surface and ocean biogeochemistry TBD

Data Assimilation

- FV3-JEDI atmosphere + SOCA ocean/sea-ice
- Weakly coupled (separate analyses for atmosphere and ocean) for flexibility, optimal choice of algorithm, window length
- Hybrid 4D-EnVar targets, possibly EDA

Continued development of GEOS adjoint and 4D-Var plus coupled H(x) with JCSDA, but not in critical path

JEDI transition project outline – a multiphase approach

Phase I: Encompasses the first implementation of JEDI in GEOS-FP. Efforts have begun and the goal will be to complete the work in late 2022.

Phase II: Encompasses efforts beyond the first implementation, with a view towards coupled DA and MERRA-3. Phase II encompasses two distinct efforts:

Phase II a: Begins *after* Phase I completes – includes work on a new ensemble and increasing the number of vertical levels.

Phase II b: Has begun *in parallel* to Phase I – includes work on coupled DA and workflow.

Targets for first JEDI-GEOS atmospheric system

Target GEOS-FP hybrid 4D-EnVar for late 2022

JEDI components

- Central DAS, including OOPS, UFO, IODA, FV3-JEDI
- Background error using GSI reformulation in SABER
- Aerosol analysis
- FSOI

Retained current components

- GSI-based EnKF for hybridization
- JEDI run within the existing GEOS-FP scripting (replace GSI.x with JEDI.x)

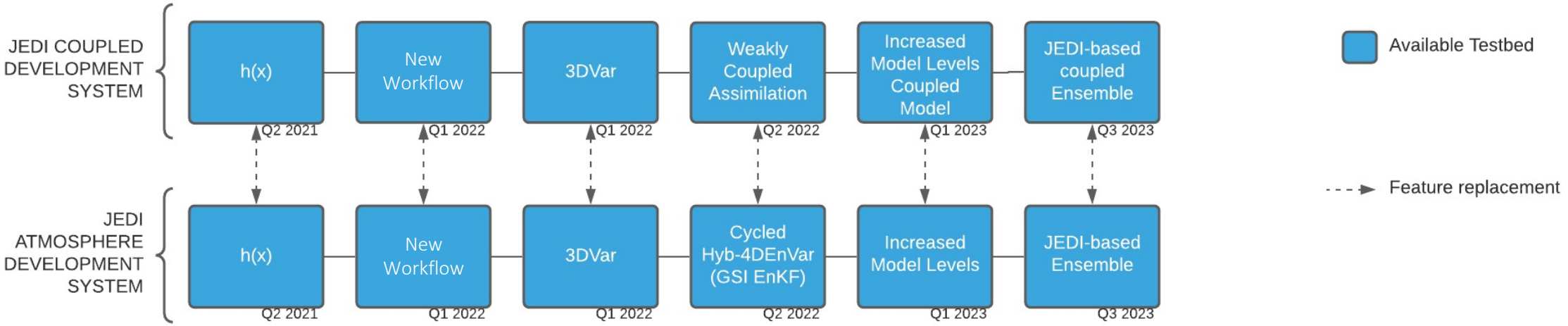
Workflow development

A new workflow will be available early in the development timeline to facilitate experimentation but won't be part of our initial implementation of JEDI in GEOS-FP. We want to avoid having a new workflow for systems that are based on a hybrid of GSI and JEDI.

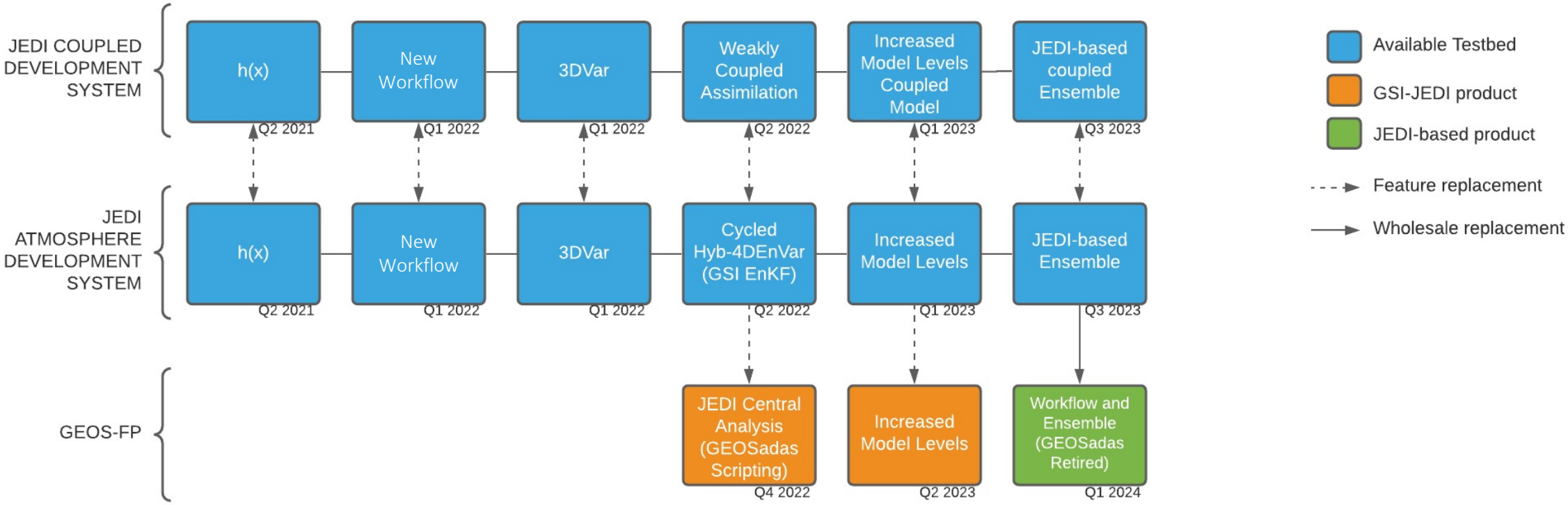
A flexible workflow system for running coupled JEDI-based applications is achieved by separating work into three key development streams:

Component	Role
Tasks	• Generic tasks needed to execute JEDI and the model.
Suites	• Suite files with generic coupling (Cylc-based). • Experiment configuration. • GUI for experiment generation and execution. • Platform specifications.
Diagnostics	• In-workflow diagnostics • Stand-alone access through Jupyter Notebooks, yaml

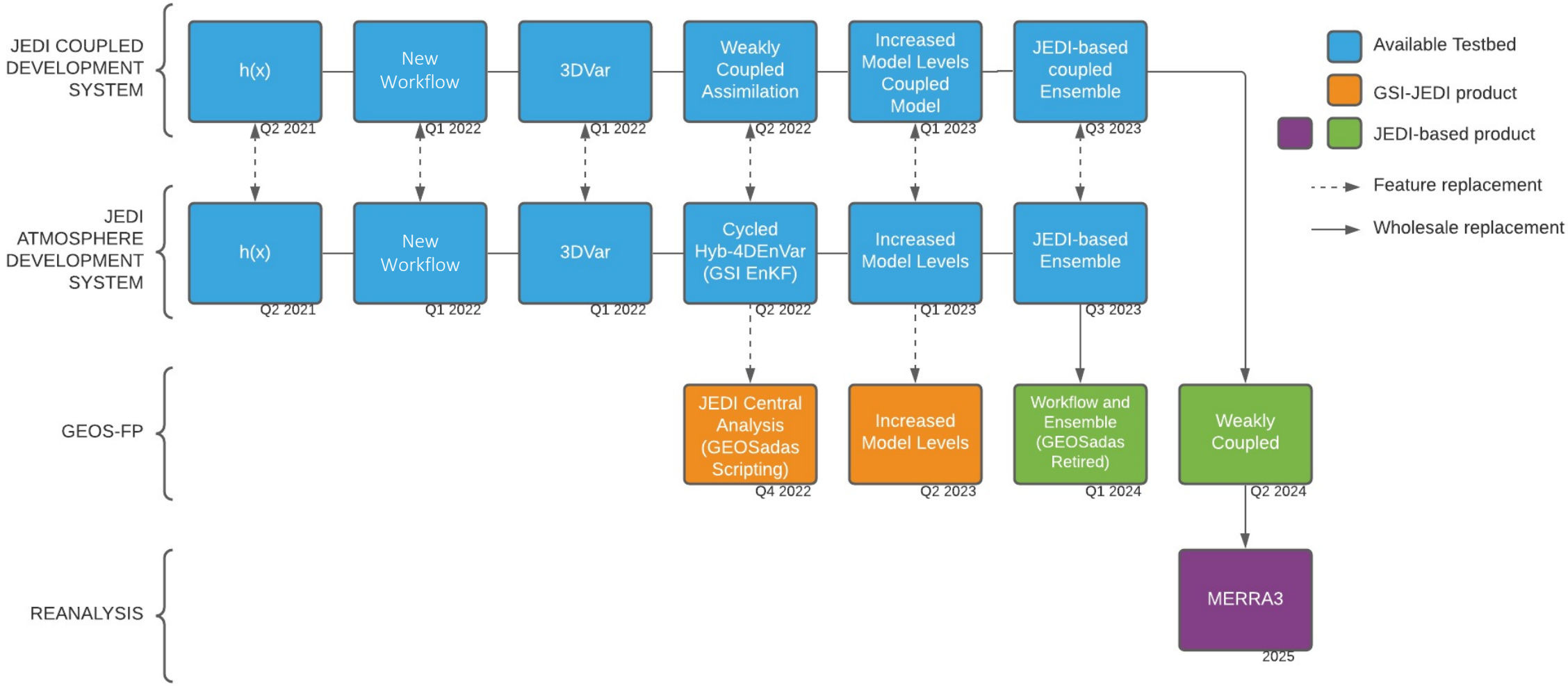
JEDI implementation roadmap



JEDI implementation roadmap



JEDI implementation roadmap



Observing system evaluation

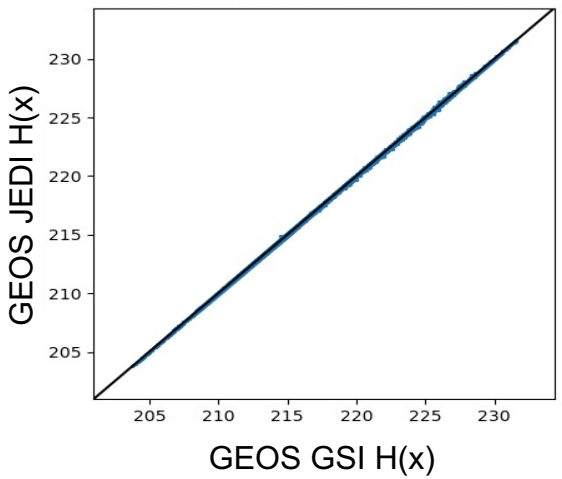
Metop-C AMSU-A
Brightness Temperature
00UTC 15 Dec 2020

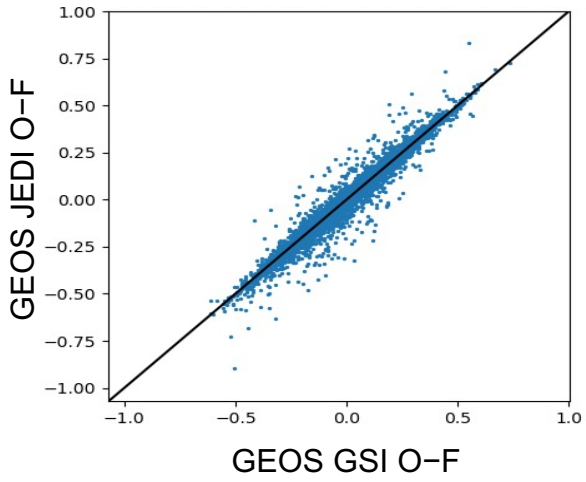
- 4D H(x) at c360 resolution
- 6-h window with 1-h bins
- Direct interp to obs locations
- GSI background, bias correction

Still to do: Implement FOV calculation and reconcile background sfc input differences

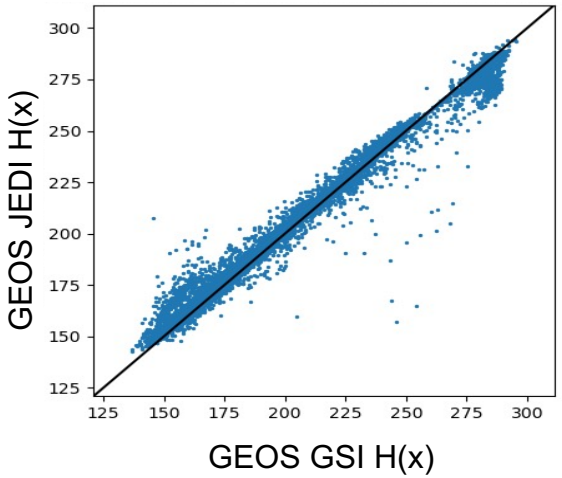
H(x) O−F

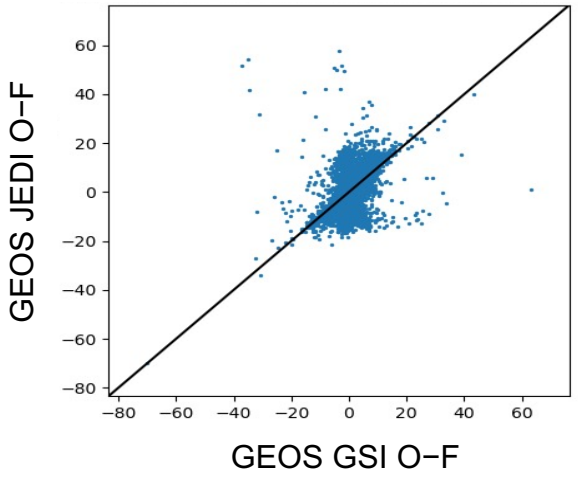
Ch.9
(upper troposphere)





Ch.2
(surface-sensitive)



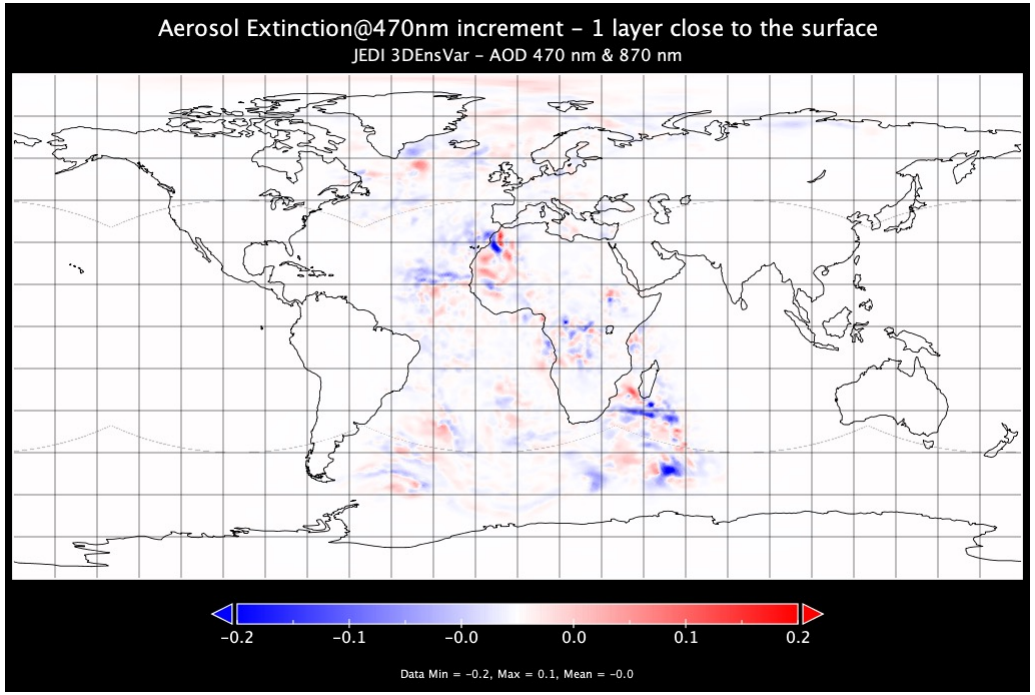


Aerosol data assimilation

Transitioning from PSAS to a JEDI-based scheme

- Upgraded analysis from 2D PSAS to 3D JEDI-based hybrid approach
- Upgraded control variable from 2D AOD to vertically resolved aerosol extinction
- Flow-dependent background error specification
- Allows observations of multi-wavelength AOD

Pathway to future observables including lidar, aerosol optical centroid height, radiances…



Aerosol extinction increments at 470 nm for near-surface model layer after one analysis cycle at C90 resolution. Observations are multi-wavelength NNR AOD at 470 & 870 nm.

In summary

- GMAO is actively developing JEDI-based systems for GEOS and will start transitioning cycling products to being JEDI-based in around a year.
- The first implementation is targeted for GEOS-FP, using JEDI for the central analysis.
- A new workflow and ecosystem for running cycled experiments is being developed and is intended to cover running GEOS from experiments to implementation.
- A phased approach is being taken. A continuously evolving coupled system with modern workflow is being developed in parallel to transitioning GEOS-FP to JEDI.
- Operational availability of a coupled JEDI-based system is targeted for 2024 and the MERRA-3 reanalysis is planned to begin in 2025.